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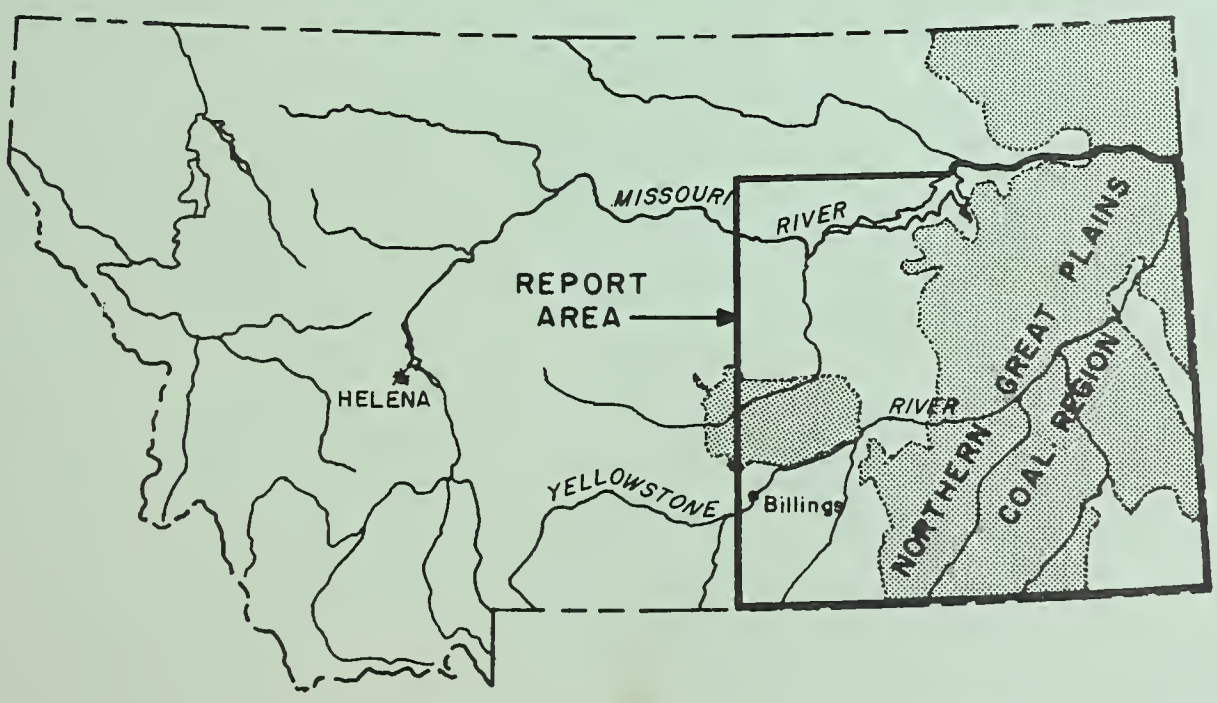

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WATER-RESOURCES INVESTIGATIONS OF THE U.S. GEOLOGICAL SURVEY IN THE NORTHERN GREAT PLAINS COAL REGION OF EASTERN MONTANA, 1975-76

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Helena, Montana

January 1976

UNITED STATES DEPARTMENT OF THE INTERIOR

Thomas S. Kleppe, Secretary

GEOLOGICAL SURVEY

V. E. McKelvey, Director

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WATER-RESOURCES INVESTIGATIONS OF THE U.S. GEOLOGICAL SURVEY IN THE NORTHERN GREAT PLAINS COAL REGION OF EASTERN MONTANA, 1975-76

INTRODUCTION

The Northern Great Plains coal region of eastern Montana has become an area of intense interest for coal companies, utilities, State and Federal agencies, universities, private citizens, landowners, and environmental groups. The possibility of large-scale mining of coal for energy or hydrocarbons has caused concern about the environmental effects on the region and has resulted in many investigations to resolve the myriad of environmental questions and problems. This report presents the water data-collection program and interpretive hydrologic investigations that are being conducted by the U.S. Geological Survey.

In 1967 there were 33 streamflow and 8 water-quality data-collection stations in the coal region of the lower Yellowstone and Missouri Rivers. In October 1975 there were 45 streamflow and 64 water-quality data-collection stations in the region for collection of streamflow, chemical-quality, sediment, and temperature data. These stations are located on all types of streams from the mainstem Yellowstone and Missouri Rivers to small ephemeral and intermittent streams that drain proposed mine areas. Types of data collected at these stations differ according to the needs of the agencies requesting the information.

Ground-water investigations are being conducted to determine the areal hydrology of the Madison Group and associated Paleozoic rocks and the areal and site hydrology of shallow aquifers in the Fort Union Formation, including the coal beds. Available data, mostly from oil tests, indicate that the Madison may yield water suitable for use in energy development in the Northern Great Plains coal region. The Madison study is directed toward developing a plan for a comprehensive investigation to begin in the near future using oil-well logs and geophysical data but progressively supplementing this information with data from new test wells.

At the present time (fall, 1975) fieldwork in the shallow ground-water study consists principally of an inventory of wells and springs and construction of wells for water sampling, aquifer testing, and water-level measurements. These data and data from future test wells will be used to construct models of the shallow hydrologic system and to attempt to predict the effects of mining and reclamation of mined lands on the ground-water system. Considerable effort has been made to coordinate this study with the work of other agencies and groups.

A computer model is being constructed to determine the effect on stream temperature of selected increases in withdrawal rates, and thus reduced flow, of the Yellowstone River from Billings to Sidney, Mont.

Subsequent sections of this report list the parameters measured in the data-collection program and show the location of stations (figs. 1-8). Most water-quality stations are separated according to Federal agency program under which the Geological Survey collects the data; suspended-sediment and

surface-water stations are presented according to data type. Background and objectives for each of the five interpretive studies in Montana, with a map showing location of areas (fig. 9), are described. Other related investigations that are being conducted from offices outside Montana are also described.

The planning and financial support for the data collection and interpretive studies are shared by the U.S. Geological Survey and the following State of Montana and Federal agencies: Montana Department of Natural Resources and Conservation, Montana Bureau of Mines and Geology, Montana Department of Highways, Montana State University, Montana Department of Community Affairs, Montana Department of Fish and Game, U.S. Bureau of Reclamation, U.S. Army Corps of Engineers, U.S. Bureau of Land Management, and Environmental Protection Agency.

DATA-COLLECTION PROGRAMS

USGS National Stream Quality Accounting Network Water-Quality Stations

The National Stream Quality Accounting Network was designed to meet the needs of agencies or groups involved in water-quality planning and management on a national or regional scale. Periodic analyses are made for inorganic constituents and suspended sediment. Nutrients, organic constituents, biological parameters, and minor inorganic elements are measured periodically to provide information on concentration ranges and variability. The information obtained for each accounting unit in the network will provide a balanced nationwide base of water-quality data.

Stations

Map number	Station number	Name	Location	Section	Town-ship	Range
1	06130500	Musselshell River at Mosby	NW¼NW¼	11	14N	30E
2	06132000	Missouri River below Fort Peck Dam	NW¼	6	26N	42E
3	06174500	Milk River at Nashua	NE¼NE¼	1	27N	41E
4	06185500	Missouri River near Culbertson[1]	SE¼NW¼	3	27N	56E
5	06214500	Yellowstone River at Billings[2]	NE¼NE¼	34	1S	26E
6	06294700	Bighorn River at Bighorn	NE¼NE¼	33	5N	34E
7	06308500	Tongue River at Miles City	SE¼	23	7N	47E
8	06326500	Powder River near Locate[1]	NW¼SW¼	14	8N	51E
9	06329500	Yellowstone River near Sidney[1,3]	SW¼NE¼SW¼	9	22N	59E

Parameter List

Daily

Physical - Temperature, specific conductance.

Monthly

Chemical - Bicarbonate, carbonate, calcium, magnesium, fluoride, sodium, potassium, dissolved solids, silica, chloride, sulfate, total phosphorous, total nitrate-nitrite, total Kjeldahl nitrogen.

Physical - Turbidity, pH, dissolved oxygen, suspended sediment.

Biological - Fecal coliform, fecal streptococci, phytoplankton.

Quarterly

Chemical - Total organic carbon, total and dissolved constituents (arsenic, cadmium, chromium, calcium, copper, iron, lead, manganese, mercury, selenium, zinc).

Biological - Periphyton.

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[1]Additional data obtained through programs as shown on other pages.
[2]Samples collected periodically for radiochemical analysis.
[3]Samples collected periodically for pesticide analysis.

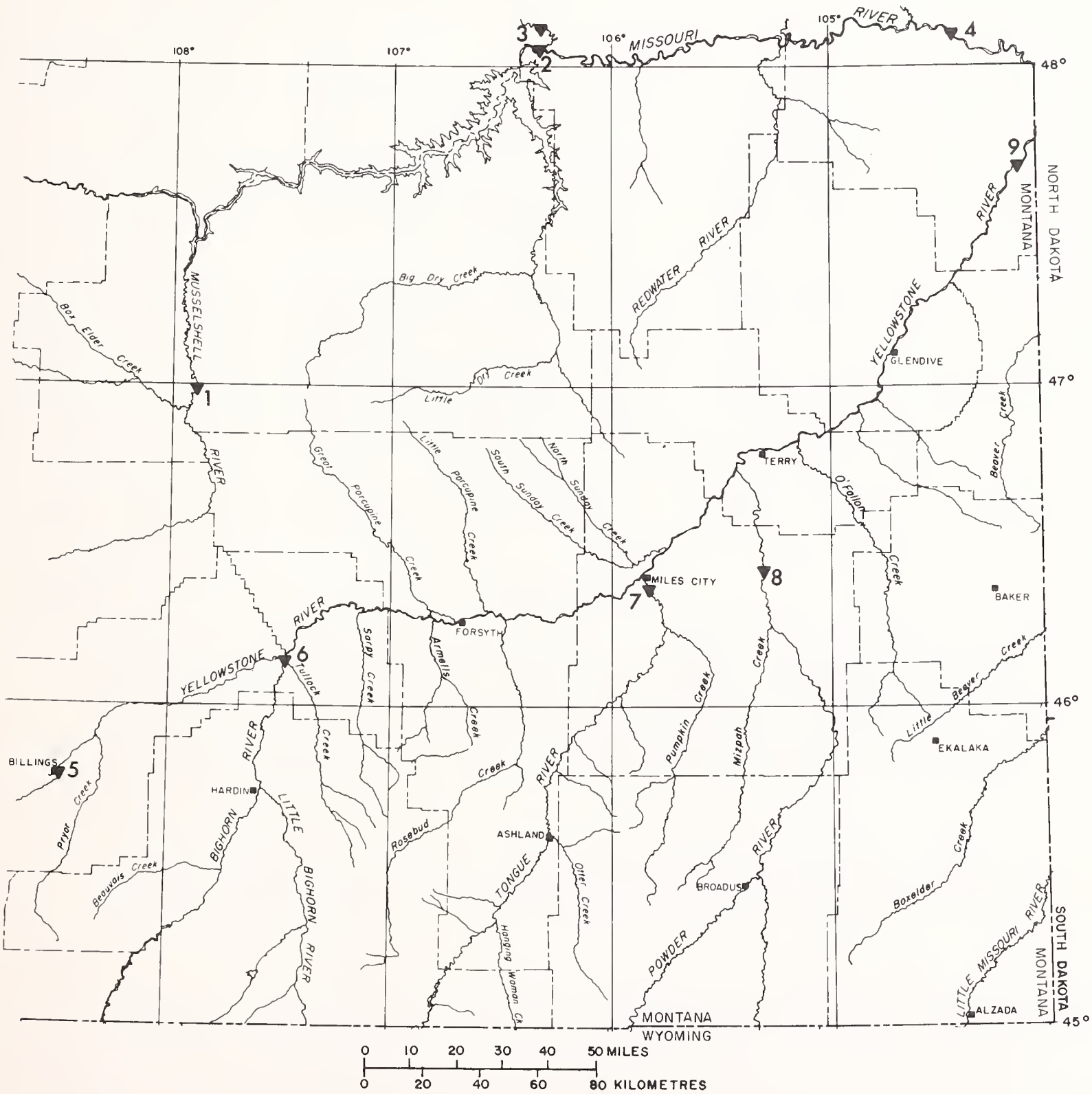

Figure 1.--National Stream Quality Accounting Network program water-quality stations.

Geological Survey Water-Quality Stations

Stations

Map number	Station number	Name	Location	Section	Town-ship	Range
1	06177500	Redwater River at Circle[1]	SW¼SW¼	11	19N	48E
2	06177825	Redwater River near Vida	SE¼	24	25N	50E
3	06217750	Fly Creek at Pompeys Pillar[2]	NW¼SE¼	23	3N	30E
4	06287000	Bighorn River near St. Xavier[2]	NW¼NE¼	16	6S	31E
5	06294000	Little Bighorn River near Hardin[2]	NE¼NE¼	19	1S	34E
6	06294980	East Fork Armells Creek near Colstrip	SE¼SW¼SW¼	28	3N	41E
7	06294991	West Fork Armells Creek near Forsyth	SW¼SW¼NW¼	21	4N	40E
8	06294995	Armells Creek near Forsyth[1]	SE¼NW¼NE¼	26	6N	39E
9	06295250	Rosebud Creek near Colstrip	SE¼SW¼NE¼	8	1S	42E
10	06295400	Rosebud Creek above Pony Creek near Colstrip	NE¼SE¼SE¼	29	2N	43E
11	06295500	Rosebud Creek near Rosebud	SW¼NE¼SW¼	12	4N	42E
12	06296003	Rosebud Creek at mouth, near Rosebud[1]	SW¼NW¼NE¼	21	6N	42E
13	06296120	Yellowstone River near Miles City[2,3]	SE¼SW¼	31	8N	47E
14	06307500	Tongue River at Tongue River Dam, near Decker	NE¼	13	8S	40E
15	06307830	Tongue River below Brandenberg Bridge, near Ashland[1,3]	NE¼SW¼NW¼	6	1N	45E
16	06324500	Powder River at Moorhead[1,3]	NW¼	8	9S	48E

Parameter List

Monthly

Chemical - Calcium, magnesium, sodium, potassium, silica, fluoride, iron, bicarbonate, carbonate, chloride, sulfate, alkalinity, total nitrate-nitrite, total phosphorous, dissolved solids, boron, total Kjeldahl nitrogen, total ammonia, biochemical oxygen demand.

Physical - Temperature, specific conductance, dissolved oxygen, pH, suspended sediment.

Quarterly

Chemical - Total constituents (arsenic, beryllium, cadmium, chromium, copper, iron, lead, lithium, manganese, mercury, molybdenum, nickel, selenium, vanadium).

Annual

Chemical - Dissolved constituents (aluminum, arsenic, beryllium, cadmium, chromium, copper, lead, mercury, manganese, nickel, zinc).

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[1] Samples collected annually for radiochemical and spectrographic analyses.
[2] Samples collected daily for temperature and specific conductance only; samples collected monthly for common constituents only.
[3] Additional data obtained through programs as shown on other pages.

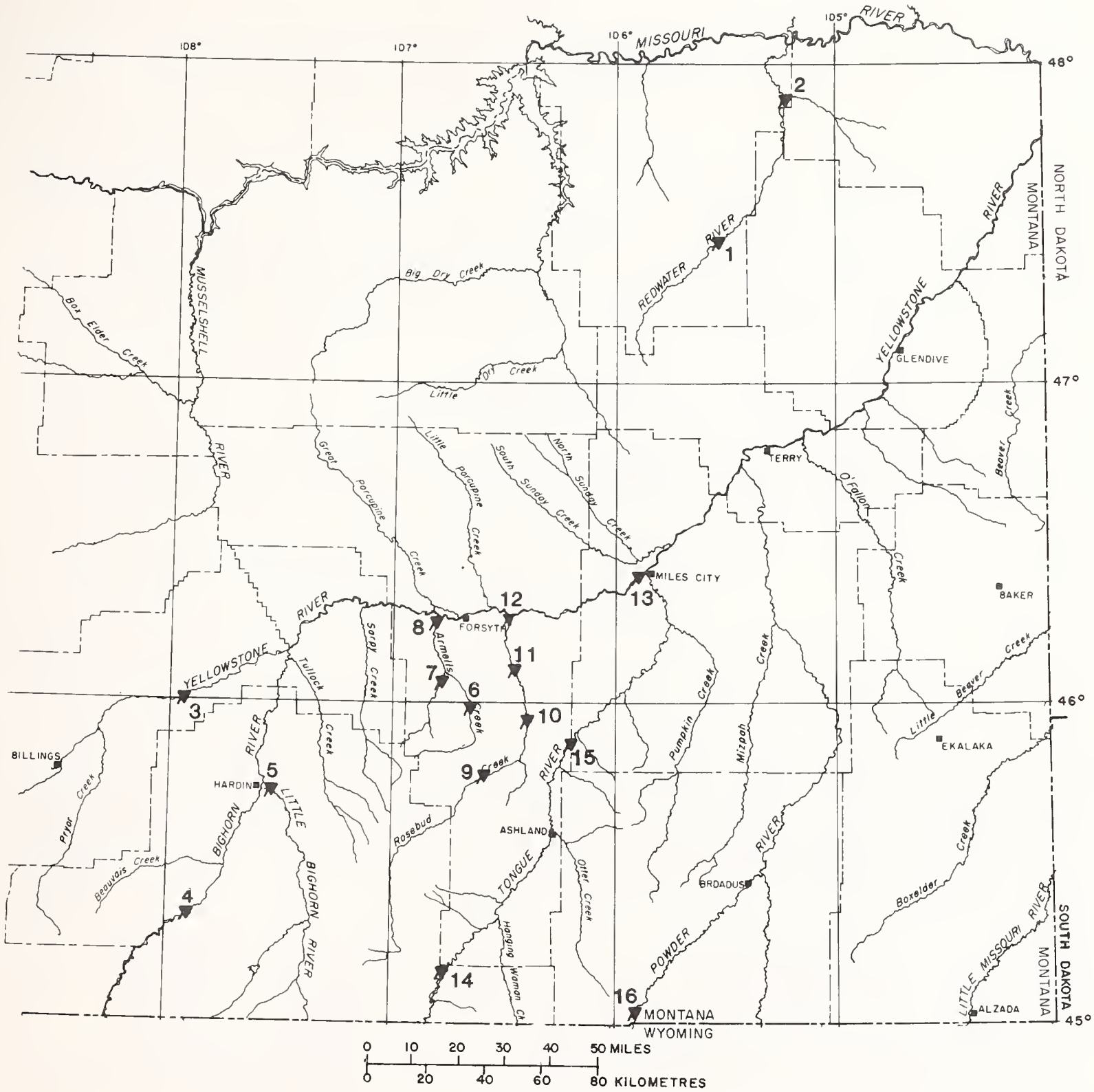

Figure 2.--Geological Survey program water-quality stations.

USGS-Environmental Protection Agency Water-Quality Stations

Stations

Map number	Station number	Name	Location	Section	Town-ship	Range
1	06205200	Yellowstone River at Laurel	SW¼SW¼SW¼	15	2S	24E
2	06217500	Yellowstone River at Huntley	N½SW¼	24	2N	27E
3	06296120	Yellowstone River near Miles City[1]	SE¼SW¼	31	8N	47E
4	06329500	Yellowstone River near Sidney[1]	SW¼NE¼SW¼	9	22N	59E

Parameter List

Biweekly

Chemical - Dissolved solids, chemical oxygen demand, total Kjeldahl nitrogen, total ammonia, total organic carbon, total phosphorous, total nitrate, total nitrate-nitrite.

Physical - Suspended solids, turbidity, temperature, specific conductance, pH, dissolved oxygen.

Biological - Total coliform, fecal coliform.

Quarterly

Chemical - Bicarbonate, carbonate, calcium, magnesium, potassium, silica, sodium, sulfate, chloride.

Under a special energy study ending April 1976, the Environmental Protection Agency is funding data collection at stations listed below. The program consists of (1) monthly sampling for common constituents, nutrients, suspended sediment, and field parameters and (2) quarterly sampling for dissolved and total metals. In addition, the same parameters are determined as supplemental data for stations 1-4. Phytoplankton and periphyton sampling is done at stations 3, 5, 7, and 8.

5	06294840	Yellowstone River at Myers	SW¼SW¼SE¼	21	6N	35E
6	06295000	Yellowstone River at Forsyth	SE¼NE¼NE¼	22	6N	40E
7	06307610	Tongue River below Hanging Woman Creek, near Birney	SW¼SE¼SE¼	1	6S	42E
8	06326530	Yellowstone River near Terry	SE¼SW¼	10	12N	51E

[1]Additional data obtained through programs as shown on other pages.

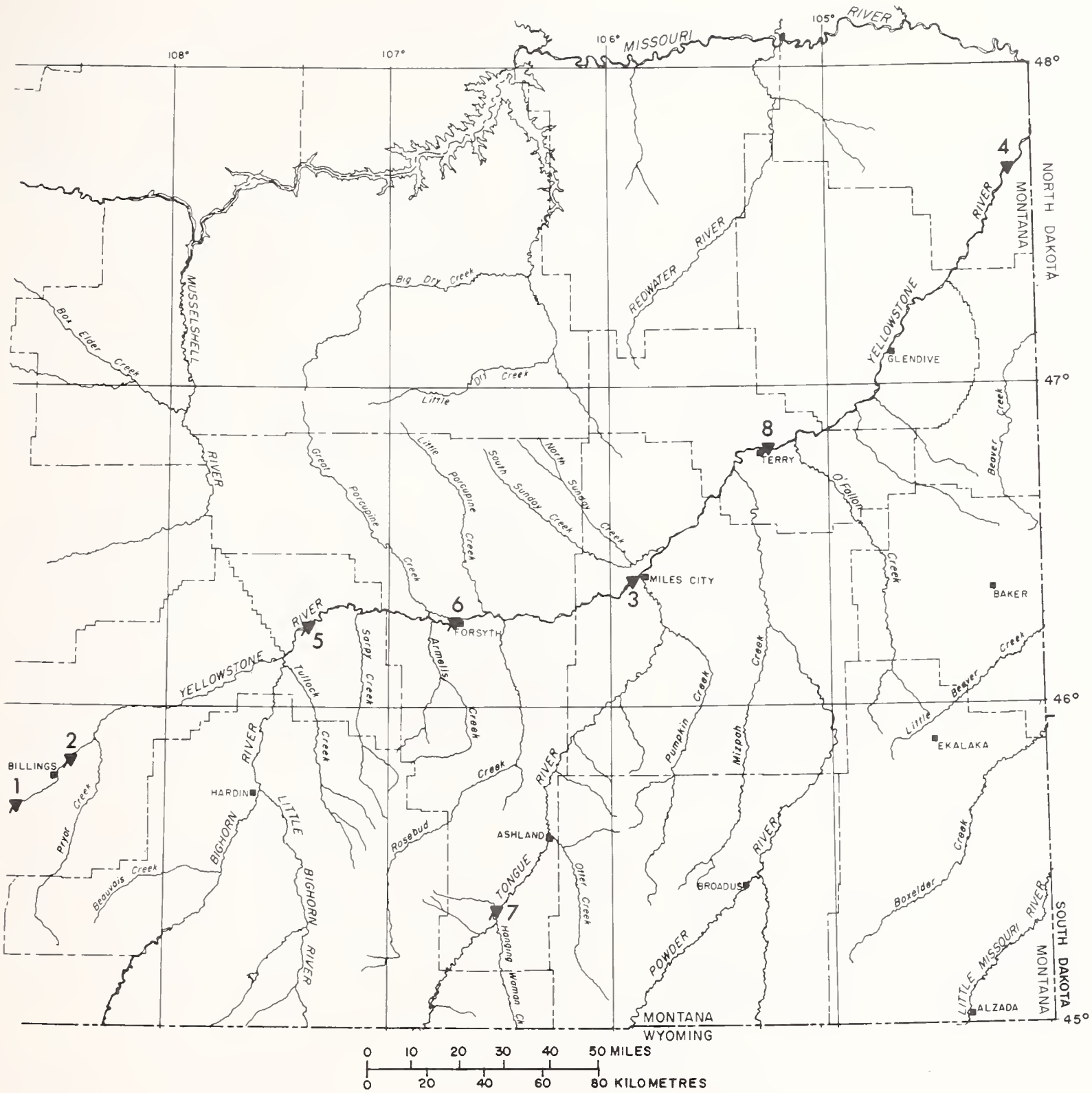

Figure 3.--USGS-Environmental Protection Agency program water-quality stations.

USGS-Bureau of Land Management Water-Quality Stations

Stations

Map number	Station number	Name	Location	Section	Town-ship	Range
1	06131200	Nelson Creek near Van Norman	E½	35	21N	43E
2	06175540	Prairie Elk Creek near Oswego[1]	SE¼SE¼	14	26N	45E
3	06294940	Sarpy Creek near Hysham[1]	SE¼SE¼	30	6N	37E
4	06295350	Greenleaf Creek near Colstrip	NW¼NW¼NW¼	29	1N	43E
5	06306100	Squirrel Creek near Decker	NW¼NW¼	14	9S	39E
6	06306300	Tongue River at State line, near Decker[2]	NW¼NE¼	33	9S	40E
7	06306800	Deer Creek near Decker	NW¼SW¼SW¼	10	9S	41E
8	06307510	Fourmile Creek near Birney	NE¼NW¼NE¼	28	7S	41E
9	06307530	Bull Creek near Birney	NE¼SW¼NW¼	28	6S	42E
10	06307600	Hanging Woman Creek near Birney	N½NW¼SE¼	19	6S	43E
11	06307615	Cook Creek near Birney	SW¼NE¼NW¼	25	5S	42E
12	06307670	Bear Creek at Otter	N½	2	7S	45E
13	06307730	Threemile Creek near Ashland	NW¼SE¼SE¼	3	4S	45E
14	06307740	Otter Creek at Ashland[1]	NE¼NE¼SE¼	11	3S	44E
15	06307810	Beaver Creek near Ashland	NW¼SE¼NE¼	34	1N	44E
16	06307830	Tongue River below Brandenberg Bridge, near Ashland[2,3]	NE¼SW¼NW¼	6	1N	45E
17	06307840	Liscom Creek near Ashland	SE¼NW¼NW¼	27	2N	45E
18	06307890	Foster Creek near Volborg	NE¼SE¼NW¼	12	3N	46E
19	06308080	Pumpkin Creek near Sonnette	NE¼SE¼SE¼	29	3S	48E
20	06308160	Pumpkin Creek near Loesch	NW¼	31	1S	49E
21	06308170	Little Pumpkin Creek near Volborg	N½	6	1S	49E
22	06308190	Pumpkin Creek near Volborg	W½	5	1N	49E
23	06308400	Pumpkin Creek near Miles City[1]	SE¼NW¼SW¼	35	6N	48E
24	06326050	Mizpah Creek at Olive	SW¼	26	3S	50E
25	06326200	Mizpah Creek near Volborg	SW¼	9	2N	51E
26	06326300	Mizpah Creek near Mizpah[1]	NW¼NE¼SW¼	24	6N	51E
27	06329200	Burns Creek near Savage	NE¼SE¼SE¼	27	19N	57E

Parameter List

Monthly

Chemical - Calcium, magnesium, sodium, potassium, silica, fluoride, iron, bicarbonate, carbonate, chloride, sulfate, alkalinity, total nitrate-nitrite, total phosphorous, dissolved solids, boron, total Kjeldahl nitrogen, total ammonia, biochemical oxygen demand.

Physical - Temperature, specific conductance, dissolved oxygen, pH, suspended sediment.

Quarterly

Chemical - Total constituents (arsenic, beryllium, cadmium, chromium, copper, iron, lead, lithium, manganese, mercury, molybdenum, nickel, selenium, vanadium).

Parameter List (cont'd)

Annual

Chemical - Dissolved constituents (aluminum, arsenic, beryllium, cadmium, chromium, copper, lead, mercury, manganese, nickel, zinc).

---

[1]Samples collected annually for radiochemical and spectrographic analyses.
[2]Under above program, continuous monitoring of temperature, pH, specific conductance, turbidity, and dissolved oxygen only.
[3]Additional data obtained through programs as shown on other pages.

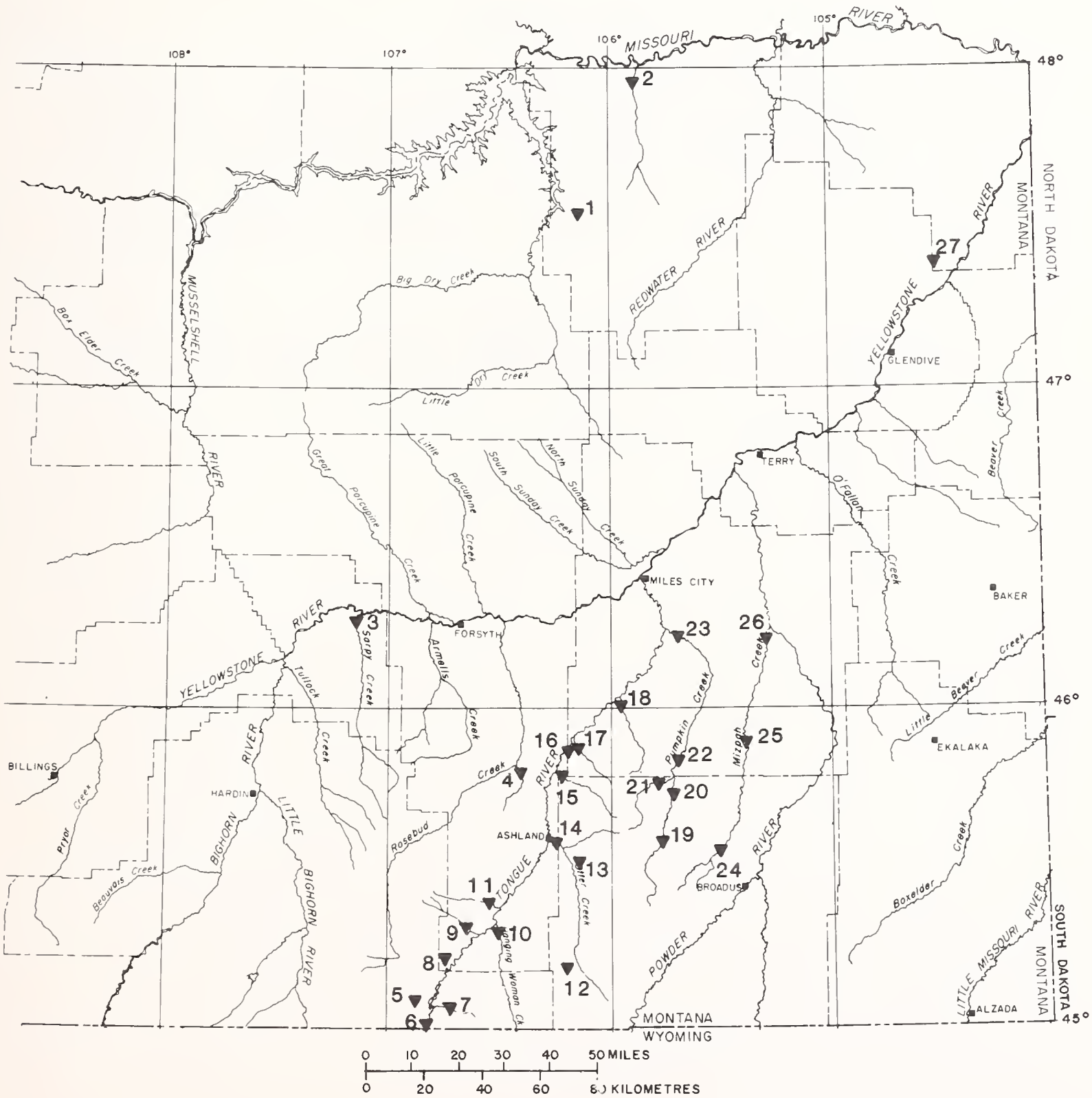

Figure 4.--USGS-Bureau of Land Management program water-quality stations.

USGS-Montana Department of Fish and Game Water-Quality Stations

Stations

Map number	Station number	Name	Location	Section	Town-ship	Range
1	06130680	Big Dry Creek at Jordan	SW¼NE¼SW¼	17	18N	38E
2	06130950	Little Dry Creek near Van Norman	NE¼NE¼NE¼	9	18N	42E
3	06131120	Timber Creek near Van Norman	E½	13	19N	43E
4	06175580	Sand Creek near Wolf Point	SE¼SE¼SE¼	12	26N	46E

Parameter List

Quarterly

Chemical - Calcium, magnesium, sodium, potassium, silica, fluoride, iron, bicarbonate, carbonate, chloride, sulfate, total nitrate-nitrite, total phosphorous, dissolved solids, boron, total Kjeldahl nitrogen, total ammonia, dissolved constituents (aluminum, arsenic, beryllium, cadmium, chromium, copper, lead, mercury, manganese, nickel, zinc).

Physical - Temperature, specific conductance, dissolved oxygen, pH, suspended sediment, turbidity.

Semiannual

Chemical - Total constituents (arsenic, beryllium, cadmium, chromium, copper, iron, lead, lithium, manganese, mercury, molybdenum. nickel, selenium, vanadium).

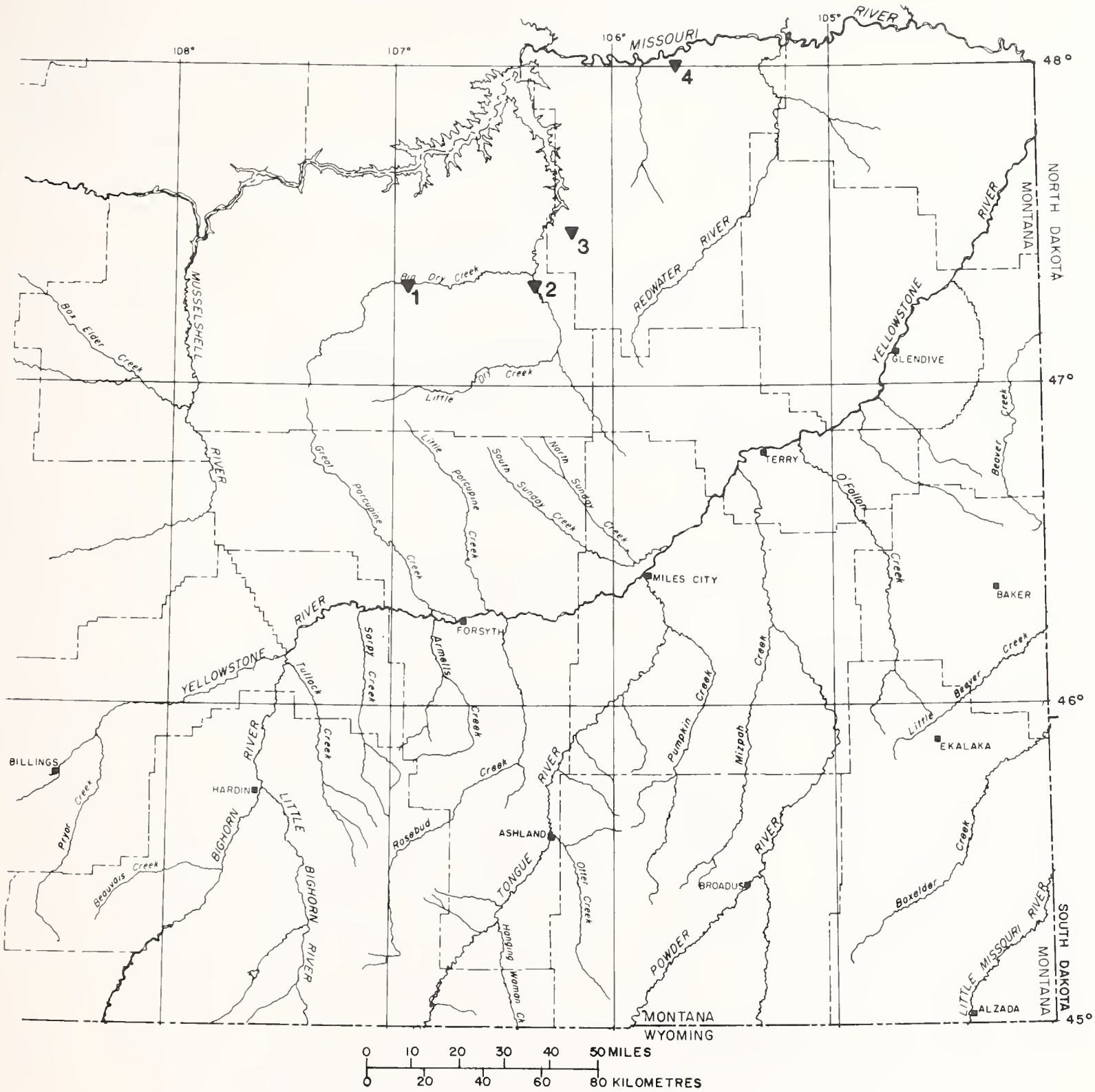

Figure 5.--USGS-Montana Department of Fish and Game program water-quality stations.

Suspended-Sediment Daily Stations

Stations

Map number	Station number	Name	Location	Section	Town-ship	Range
1	06115200	Missouri River near Landusky (U.S. Geological Survey-U.S. Army Corps of Engineers cooperative program)	NW¼NE¼	31	22N	24E
2	06185500	Missouri River near Culbertson[1] (U.S. Geological Survey-U.S. Army Corps of Engineers cooperative program)	SE¼NW¼	3	27N	56E
3	06294000	Little Bighorn River near Hardin[1] (U.S. Geological Survey program)	NE¼NE¼	19	1S	34E
4	06307830	Tongue River below Brandenberg Bridge, near Ashland[1] (U.S. Geological Survey program)	NE¼SW¼NW¼	6	1N	45E
5	06324500	Powder River at Moorhead[1] (U.S. Geological Survey program)	NW¼	8	9S	48E
6	06324710	Powder River at Broadus[1] (U.S. Geological Survey program)	SE¼	3	5S	51E
7	06326500	Powder River near Locate[1] (U.S. Geological Survey program)	NW¼SW¼	14	8N	51E
8	06329500	Yellowstone River near Sidney[1] (U.S. Geological Survey-U.S. Army Corps of Engineers cooperative program)	SW¼NE¼SW¼	9	22N	59E

Parameter List

Daily

Physical - Suspended sediment, temperature.

Periodic

Physical - Particle size.

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[1]Additional data obtained through programs as shown on other pages.

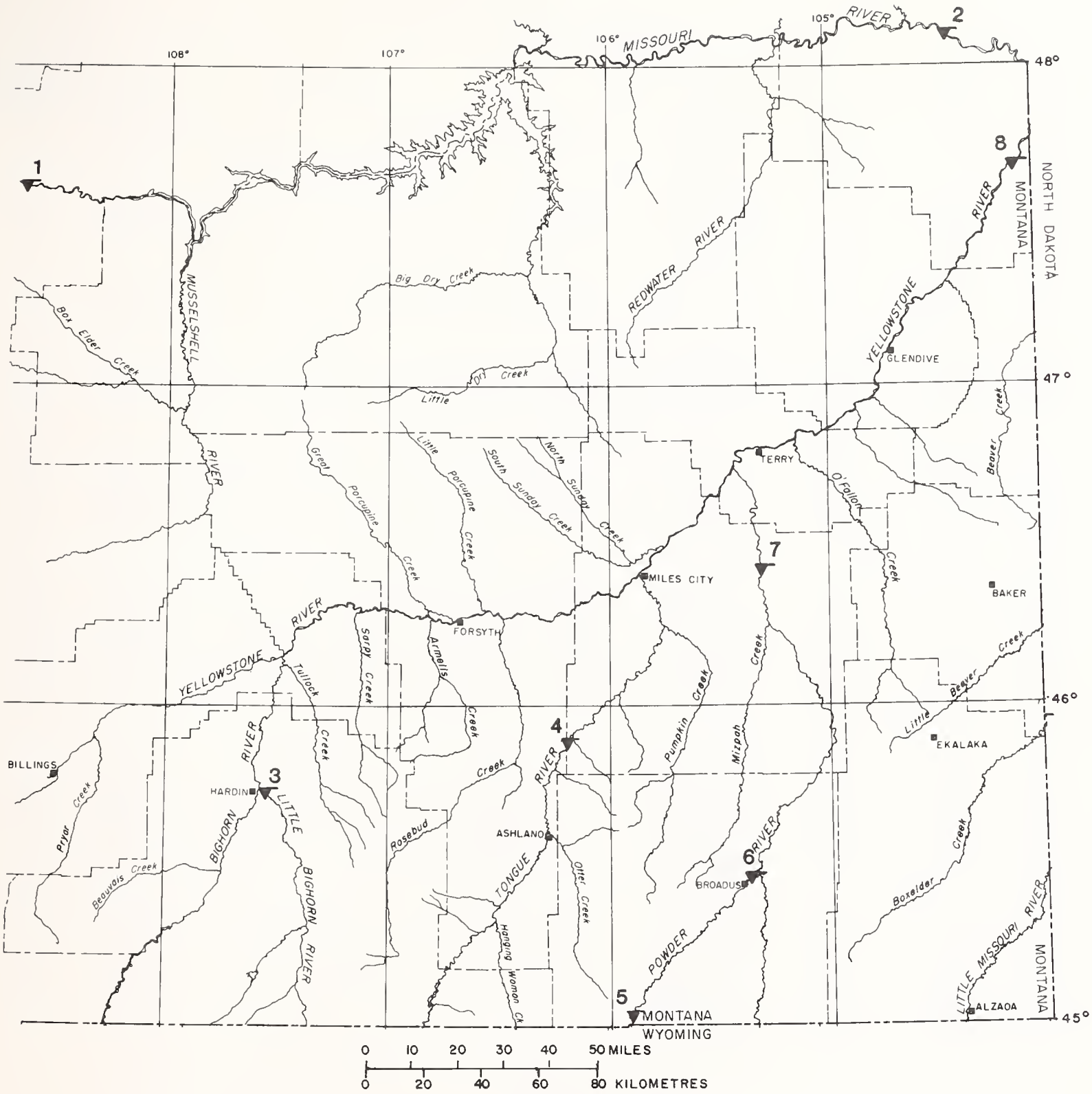

Figure 6.--Suspended-sediment daily stations.

Streamflow Stations

Map number	Station number	Name	Location	Section	Town-ship	Range
1	06115200	Missouri River near Landusky	NW¼NE¼	31	22N	24E
2	06127500	Musselshell River at Musselshell	S½SW¼	20	9N	29E
3	06130500	Musselshell River at Mosby	NW¼NW¼	11	14N	30E
4	06131000	Big Dry Creek near Van Norman	NW¼SE¼NW¼	3	18N	42E
5	06131200	Nelson Creek near Van Norman	SW¼NW¼	36	21N	43E
6	06131500	Fort Peck Lake at Fort Peck		14	26N	41E
7	06132000	Missouri River below Fort Peck Dam	NW¼	6	26N	42E
8	06174500	Milk River at Nashua	NE¼NE¼	1	27N	41E
9	06175540	Prairie Elk Creek near Oswego	SE¼SE¼	14	26N	45E
10	06177000	Missouri River near Wolf Point	SW¼NW¼	28	27N	48E
11	06177500	Redwater River at Circle	SW¼SW¼	11	19N	48E
12	06177825	Redwater River near Vida	SE¼	24	25N	50E
13	06185500	Missouri River near Culbertson	SE¼NW¼	3	27N	56E
14	06214500	Yellowstone River at Billings	NE¼NE¼	34	1N	26E
15	06216000	Pryor Creek at Pryor	NE¼NW¼NE¼	5	5S	26E
16	06217750	Fly Creek at Pompeys Pillar	NW¼SE¼	23	3N	30E
17	06286400	Bighorn Lake near St. Xavier	SW¼SE¼	18	6S	31E
18	06287000	Bighorn River near St. Xavier	NW¼NE¼	16	6S	31E
19	06288200	Beauvais Creek near St. Xavier	West line	15	4S	30E
20	06289000	Little Bighorn River at State line, near Wyola	SW¼NW¼	36	9S	33E
21	06294000	Little Bighorn River near Hardin	NE¼NE¼	19	1S	34E
22	06294690	Tullock Creek near Bighorn	NE¼NE¼NE¼	19	4N	35E
23	06294700	Bighorn River at Bighorn	NE¼NE¼	33	5N	34E
24	06294940	Sarpy Creek near Hysham	SE¼SE¼	30	6N	37E
25	06294995	Armells Creek near Forsyth	SE¼NW¼NE¼	26	6N	39E
26	06295250	Rosebud Creek near Colstrip	SE¼SW¼NE¼	3	1S	42E
27	06296003	Rosebud Creek at mouth near Rosebud	SW¼NW¼NE¼	21	6N	42E
28	06306100	Squirrel Creek near Decker	NW¼NW¼	14	9S	39E
29	06306250	Prairie Dog Creek near Acme, Wyo.	NE¼SW¼SW¼	23	58N	83W
30	06306300	Tongue River at State line, near Decker	NW¼NE¼	33	9S	40E
31	06307500	Tongue River at Tongue River Dam, near Decker	NE¼	13	8S	40E
32	06307600	Hanging Woman Creek near Birney	N½NW¼SE¼	19	6S	43E
33	06307740	Otter Creek at Ashland	NE¼NE¼SE¼	11	3S	44E
34	06307830	Tongue River below Brandenberg Bridge near Ashland	NE¼SW¼NW¼	6	1N	45E
35	06308400	Pumpkin Creek near Miles City	SE¼NW¼SW¼	35	6N	48E
36	06308500	Tongue River at Miles City	SE¼	23	7N	47E
37	06309000	Yellowstone River at Miles City	SW¼NW¼	28	8N	47E
38	06309075	Sunday Creek near Miles City	NW¼SW¼SW¼	3	8N	47E
39	06324500	Powder River at Moorhead	NW¼	8	9S	48E
40	06324710	Powder River at Broadus	SE¼	3	5S	51E

Streamflow Stations (cont'd)

Map number	Station number	Name	Location	Section	Town-ship	Range
41	06326300	Mizpah Creek near Mizpah	NW¼NE¼SW¼	24	6N	51E
42	06326500	Powder River near Locate	NW¼SW¼	14	8N	51E
43	06326850	O'Fallon Creek at Mildred	SE¼SE¼	30	11N	54E
44	06329200	Burns Creek near Savage	West line	26	19N	57E
45	06329500	Yellowstone River near Sidney	SW¼NE¼SW¼	9	22N	59E

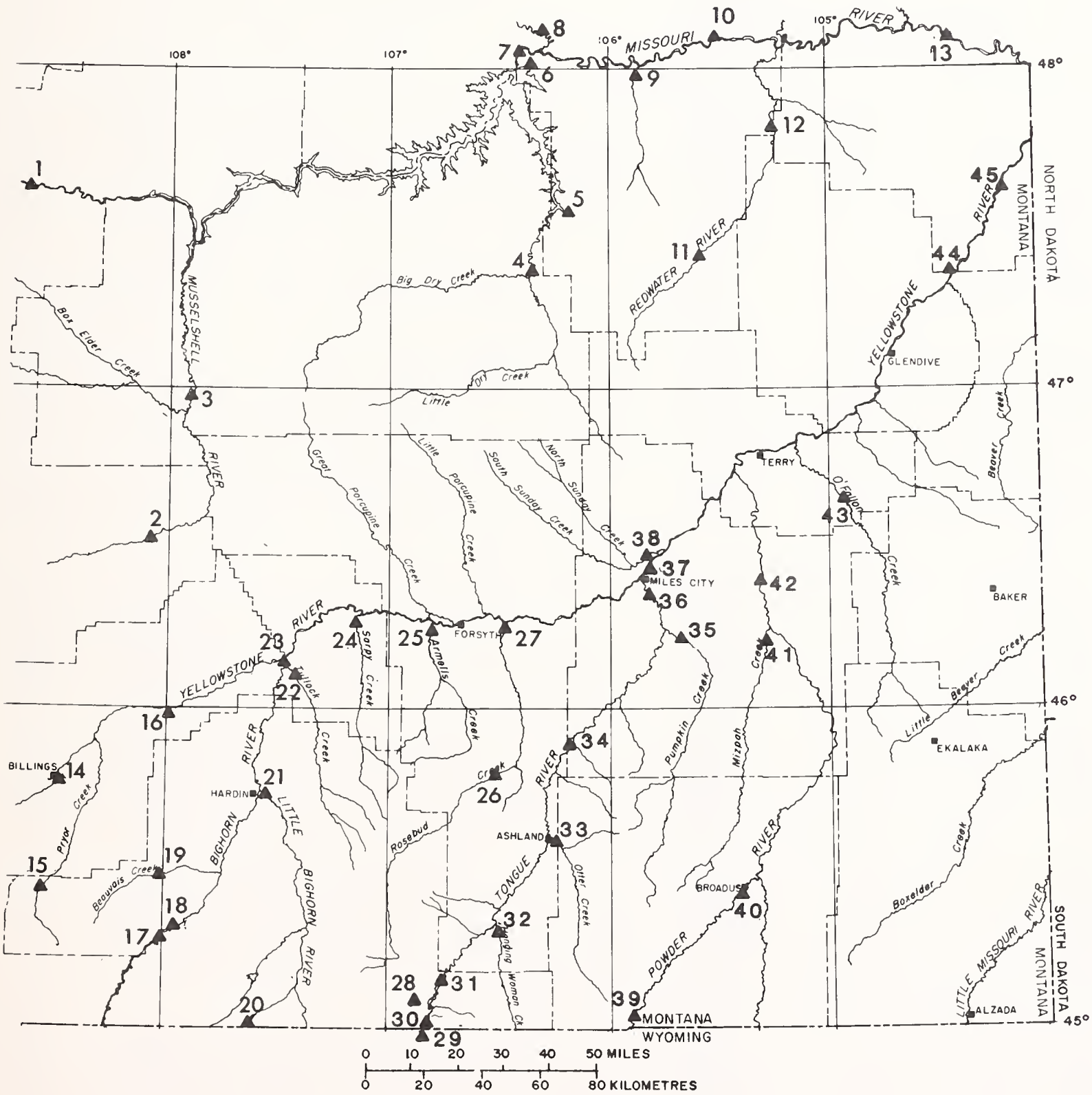

Figure 7.--Streamflow stations.

Crest-Stage Stations

The crest-stage stations listed below are maintained in cooperation with the Montana Department of Highways. The stage and discharge of annual peak flows are determined at these sites.

Map number	Name	Location	Section	Town-ship	Range
1	Fish Creek near Musselshell	NW¼SW¼	9	8N	29E
2	Musselshell River tributary near Musselshell	SW¼	30	9N	28E
3	Butts Coulee near Melstone	Center E½	9	10N	31E
4	Gorman Coulee near Cat Creek	SW¼SW¼	31	15N	29E
5	Home Creek near Sumatra	SE¼NW¼	7	10N	33E
6	Bair Coulee near Mosby	NE¼NE¼	23	15N	32E
7	Second Creek tributary No. 2 near Jordan	NE¼	25	17N	38E
8	Russian Coulee near Jordan	SW¼NE¼	11	18N	39E
9	Thompson Creek tributary near Cohagen	NW¼SW¼	19	14N	42E
10	Spring Creek tributary near Van Norman	NW¼NE¼	12	17N	42E
11	Timber Creek tributary near Van Norman	SE¼NE¼	24	19N	43E
12	McGuire Creek tributary near Van Norman	NE¼SE¼	2	21N	43E
13	East Fork Sand Creek near Vida	NW¼	31	24N	48E
14	Cow Creek tributary near Vida	SE¼	36	23N	48E
15	East Fork Duck Creek near Brockway	W½	31	17N	47E
16	West Fork Sullivan Creek near Richey	SW¼SW¼	31	21N	51E
17	Wolf Creek tributary near Vida	SE¼	15	25N	48E
18	Missouri River tributary No. 6 near Wolf Point	NW¼NW¼	32	27N	48E
19	North Fork East Redwater River tributary near Richey	SE¼NE¼	36	25N	51E
20	Missouri River tributary No. 3 near Culbertson	Center	8	27N	56E
21	Little Bighorn River tributary near Wyola	SE¼NW¼	14	8S	35E
22	Long Otter Creek near Lodgegrass	NW¼SE¼	28	4S	35E
23	Andresen Coulee near Custer	W½	30	4N	34E
24	Tullock Creek tributary near Hardin	NW¼NW¼	33	1N	36E
25	Sarpy Creek tributary near Colstrip	SW¼SW¼	16	2N	37E
26	Buckingham Coulee near Myers	SW¼	25	6N	35E
27	Unknown Creek near Bighorn	SE¼	12	5N	34E
28	Armells Creek tributary near Colstrip	SE¼SE¼	26	4N	40E
29	Rosebud Creek tributary near Busby	NE¼	13	3S	39E
30	Spring Creek near Decker	SE¼	33	8S	40E
31	Leaf Rock Creek near Kirby	Center	35	7S	39E
32	Canyon Creek near Birney	SW¼	11	7S	41E
33	Tie Creek near Birney	SW¼SE¼	22	4S	42E
34	Cow Creek near Fort Howes Ranger Station near Otter	SW¼NW¼	30	6S	46E
35	Brian Creek near Ashland	SW¼SW¼	11	5S	45E
36	Spring Creek near Ashland	NW¼	27	3S	44E
37	Walking Horse Creek near Ashland	NW¼	3	3S	44E
38	Stebbins Creek near Ashland	Center	34	2S	43E
39	Stebbins Creek at mouth, near Ashland	NW¼	27	2S	44E
40	Jack Creek near Volborg	NE¼NW¼	26	4N	47E

Crest-Stage Stations (cont'd)

Map number	Name	Location	Section	Town-ship	Range
41	Sixmile Creek tributary near Epsie	SW¼SW¼	36	3S	48E
42	Basin Creek tributary near Volborg	NW¼	31	2N	49E
43	Deer Creek tributary near Volborg	SW¼SW¼	4	3N	50E
44	LaGrange Creek near Volborg	NE¼NW¼	18	4N	50E
45	Middle Fork Froze to Death Creek tributary near Ingomar	NE¼	35	10N	34E
46	Anderson Creek at Vananda	SE¼NE¼	6	7N	38E
47	Short Creek near Forsyth	NW¼	12	6N	40E
48	Snell Creek near Hathaway	NW¼	7	6N	45E
49	Reservation Creek near Miles City	SE¼NE¼	9	7N	46E
50	North Fork Sunday Creek tributary at Rock Springs	SE¼	1	12N	43E
51	Dry House Creek near Angela	SE¼SW¼	22	11N	44E
52	North Fork Sunday Creek tributary No. 2 near Angela	NE¼	4	9N	45E
53	Tree Coulee near Kinsey	NE¼NW¼	10	9N	47E
54	Deep Creek near Kinsey	SE¼SE¼	1	9N	48E
55	Ash Creek near Locate	N½	17	7N	50E
56	Badger Creek at Biddle	NW¼SE¼	4	9S	52E
57	Sand Creek near Broadus	SE¼	5	5S	51E
58	Cut Coulee near Mizpah	NE¼SW¼	36	5N	52E
59	Meyers Creek near Locate	SE¼	1	7N	51E
60	Locate Creek tributary near Locate	SW¼SE¼	23	8N	52E
61	East Fork Little Powder River tributary near Hammond	NW¼SE¼	22	6S	54E
62	Powder River tributary near Powderville	NE¼NE¼	25	1N	53E
63	Cherry Creek tributary near Terry	NE¼SW¼	25	13N	50E
64	O'Fallon Creek near Ismay	East line	30	8N	56E
65	O'Fallon Creek tributary near Ismay	SE¼	29	8N	56E
66	Spring Creek tributary near Fallon	NE¼NE¼	13	12N	53E
67	Yellowstone River tributary No. 4 near Fallon	SW¼	23	13N	52E
68	Yellowstone River tributary No. 5 near Marsh	SW¼	21	14N	54E
69	Timber Fork Creek tributary near Lindsay	SW¼SW¼	36	17N	51E
70	Thirteenmile Creek tributary near Bloomfield	SE¼SE¼	9	19N	54E
71	Fox Creek tributary near Lambert	NW¼SW¼	24	22N	55E
72	First Hay Creek near Sidney	SE¼	16	24N	58E
73	Griffith Creek tributary near Glendive	NE¼NW¼	35	16N	56E
74	Yellowstone River tributary No. 6 near Glendive	NW¼SE¼	8	16N	56E
75	Alkali Creek tributary near Sidney	SW¼NE¼	7	20N	60E
76	Krug Creek tributary No. 2 near Wibaux	NW¼NW¼	6	14N	59E
77	South Fork Horse Creek tributary near Wibaux	SW¼SE¼	11	12N	58E
78	Pennel Creek near Baker	South line	36	9N	59E
79	Deep Creek near Baker	SW¼	2	6N	59E
80	Lame Jones Creek tributary near Willard	SE¼SE¼	11	5N	57E
81	Wolf Creek near Hammond	SE¼	5	8S	57E
82	North Creek near Alzada	SE¼NW¼	7	9S	59E

Crest-Stage Stations (cont'd)

Map number	Name	Location	Section	Town-ship	Range
83	Little Missouri River tributary near Albion	SW¼NW¼	21	7S	61E
84	Box Elder Creek tributary near Albion	SE¼	19	5S	59E
85	Coal Creek near Mill Iron	NW¼SW¼	26	2N	59E
86	North Fork Coal Bank Creek near Mill Iron	SW¼	12	2N	61E
87	Soda Creek tributary near Webster	NE¼	23	3N	61E

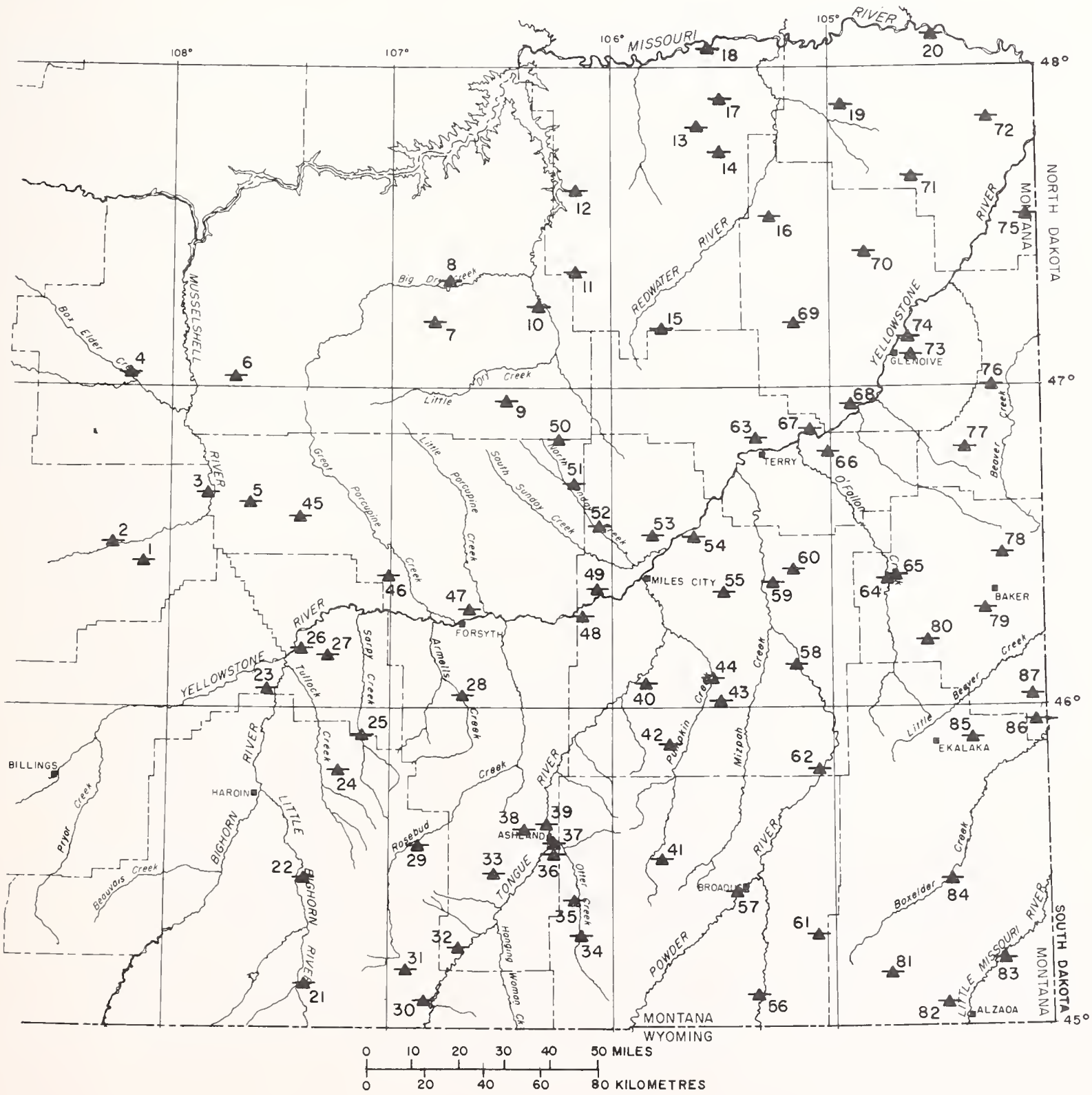

Figure 8.--Crest-stage stations.

INTERPRETIVE STUDIES

Availability of Water from the Madison Aquifer (Project MT75-049)

Scattered and incomplete data indicate that the Madison aquifer (carbonates of the Madison Group and associated Paleozoic rocks) may yield as much as 2,200 gallons per minute (140 litres per second) to wells. However, the existing data are inadequate to predict the quantity and quality of water the aquifer will yield and the effects of development on the system.

The purposes of this study are to evaluate existing data and techniques and to develop a comprehensive plan of investigation of the Madison (see fig. 9). The following approach is planned:

I. Evaluate and refine the existing conceptual model.

   A. List the model constraints and the possible consequences if the system is stressed.

   B. Determine the reliability of the constraints by comparing different types of data and placing various hypothetical stresses on the system.

   C. Modify the model to fit the available data.

II. Evaluate selected techniques that may be useful hydrologic tools in a comprehensive study of the Madison aquifer.

   A. Examine surface geophysical methods as to their application in extending point data in space and their relative costs and manpower needs. The main emphasis will be on seismic methods.

   B. Examine borehole geophysical methods as to which logs give optimum information, their relation to porosity and permeability, and their application in extending point data in space.

   C. Determine the possible relation between structure, geologic history, and various geohydrologic parameters.

   D. Examine sedimentary petrology as a tool to relate porosity and permeability to the hydrologic system, to determine the factors that control permeability, and to determine the parameters that define the flow system. Relate the results to items A-C above.

   E. Examine the use of geochemical techniques to describe the aquifer system and to develop a geochemical model.

III. Combine the conceptual model with the most promising techniques and plan a comprehensive study of the Madison aquifer.

A. Select test-hole locations, outline the geohydrologic tests to be made and, concurrently, prepare test-drilling specifications and a drilling contract.

B. Specify additional field duties and interpretive work necessary to extrapolate point data and further refine the conceptual model.

C. Refine and extend the existing preliminary model of the Madison Group to include the associated Paleozoic rocks.

D. Outline continuing studies necessary to define the system and to predict water quality, quantity, and consequences of development.

Because of the widespread interest and concern about the possible regional effects of development of the Madison aquifer, a regional planning study of the aquifer in Montana, North Dakota, South Dakota, Wyoming, and Nebraska was initiated (see fig. 10). Since the objectives of the Montana and regional studies were nearly identical, the studies were merged. The merger coordinated district and regional programs and minimized duplication of effort. Three major efforts have been completed. A preliminary digital simulation model of the aquifer has been developed. Surface and borehole geophysical studies have been started to test methods to relate geophysical data to the geohydrology of the Madison and to extend point data in space. Plans for a comprehensive study have been incorporated in a regional planning document that has been released as an open-file report.

Cooperating agencies: Old West Regional Commission
Montana Bureau of Mines and Geology

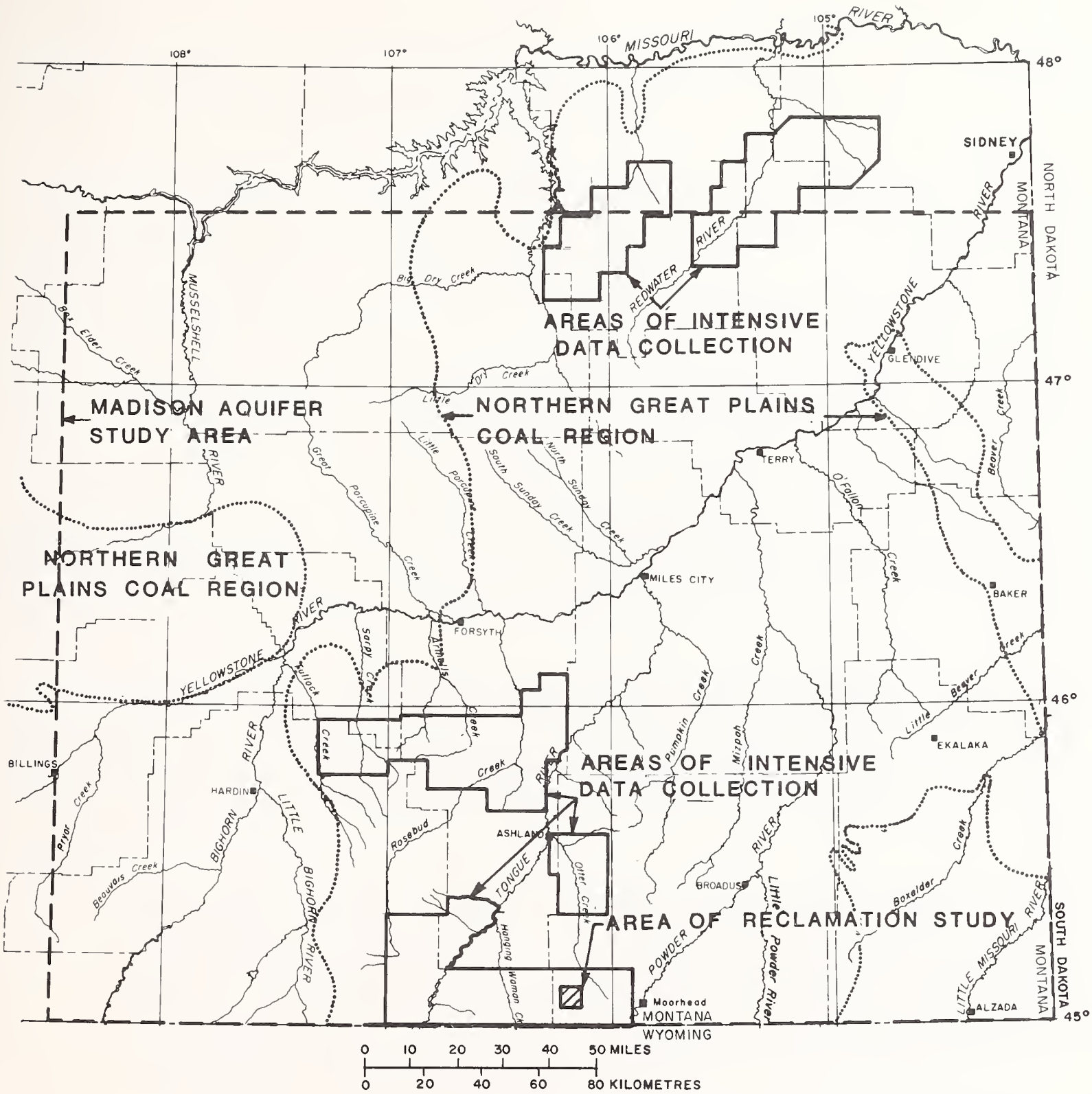

Figure 9.--Ground-water interpretive-study areas.

Effects of Mining and Related Activities on the Shallow Ground-Water System (Project MT75-048)

Strip mining and the related aspects of coal development can be expected to cause ground-water levels and ground-water quality to change near the area of development in the shallow aquifers in eastern Montana. The shallow aquifers are principally alluvium along stream valleys and relatively thin discontinuous sandstone and coal beds separated by shale overlying the Pierre Shale of Late Cretaceous age. Ground-water supplies are fairly evenly distributed, but small in amount, and are developed mostly for domestic and stock use. Data, data interpretation, and prediction of the effects of mining and related activities on the shallow ground-water system are needed by the public, industry, and government to aid in the wise development of the coal resources.

Areas underlain by the best quality coal in greatest amounts are of immediate importance to leasing for mining; these areas are scheduled for intensive data collection, as shown on figure 9. The study north of the Yellowstone River is of a reconnaissance nature, consisting principally of an inventory of existing wells and collection of water samples for chemical analysis.

The study south of the Yellowstone River is a comprehensive analysis of the hydrologic system. The overall study area, whose boundaries may require adjustment in the future, is in general bounded on the north by the Yellowstone, on the east by the Powder and Little Powder Rivers, on the south by Wyoming, and on the west by the Bighorn and Little Bighorn Rivers.

The objectives of this study are several:

1. Define the regional hydrologic system of the aquifers above the Pierre Shale, including the interrelations between the most extensive aquifers, hydrologic characteristics, extent and boundaries of aquifers, water-quality variations, aquifer recharge and discharge, and streamflow. Definition of the system will initially be in areas planned for intensive data collection, followed by definition for the overall study area.

2. Obtain a detailed quantitative understanding of the flow system in relatively small areas of 10-20 square miles (26-52 square kilometres) in terms of ground-water recharge, movement, discharge, boundaries, and aquifer parameters. This information will form a conceptual model that will be the basis for predictive models.

3. Develop and test predictive models to assess the effects of several different levels of energy development and mining plans on regional and small-area flow systems.

4. Develop water-quality models to predict the rate and direction of leachate migration from spoil banks.

5. Utilize the predictive models to evaluate and improve the data-collection program.

Cooperating agencies:

1. U.S. Bureau of Land Management

2. Montana Bureau of Mines and Geology

3. Montana Department of Natural Resources and Conservation

Grants have been made to:

1. Montana Bureau of Mines and Geology--selected test drilling and aquifer testing.

2. Montana Department of Community Affairs--development of format and software systems to make data collected by State agencies compatible with U.S. Geological Survey and STORET computer systems.

3. Montana State University--geochemistry, mineralogy, microorganisms, and chemical reactions that occur in spoils and aquifers.

Grants are under consideration with:

1. Montana Department of Fish and Game--definition of selected chemical and biological parameters at supplemental sites along the Yellowstone River.

Site Study to Assess the Ground-Water Problems That May Affect Reclamation of Mined Lands (Project MT76-053)

Problems of mined-land reclamation and possible solutions must be known before areas underlain by Federally owned coal will be recommended for leasing. These problems range from what type of surface treatment is best to what will be the effect of surface mining on the water resources.

The principal objective of the study is to provide the data and interpretations necessary to predict the potential water-resources problems related to mining and reclamation and to suggest alternative solutions to the problems. Concurrently, a monitoring system is needed to define baseline conditions and to document changes in ground-water flow and quality caused by mining and reclamation (see fig. 9).

The study will utilize the contributions of the following groups:

1. U.S. Bureau of Land Management--land classification.

2. U.S. Bureau of Reclamation--drill and core test holes, make physiochemical analyses of cores, perform leaching experiments, and perform engineering and soil tests.

3. U.S. Geological Survey--obtain geophysical logs of test holes and correlate with cores, determine hydrologic characteristics of aquifers, install recorders for monitoring water levels, collect water samples for chemical analysis, collect related surface-water and sedimentation data, analyze all data and determine potential problems, and develop alternatives for management of the resource.

Yellowstone River Temperature Study
(Project MT00-003)

The purpose of the study is to determine the effect of possible reduction in streamflow on the temperature of the Yellowstone River from Billings to Sidney. Field data have been collected and are presently being used to develop a computer model of the energy budget for the stream. The model will be used to predict temperature changes in the river as a result of preselected withdrawal rates at any point within the reach.

Chemical and Physical Characteristics of Inflow to the Tongue River in Montana
(Project MT75-054)

During November 1975 the Tongue River Dam was closed for repairs and the discharge of the river was reduced to near-record low flow. Discharge of the stream was mainly from water in the valley alluvium and from aquifers in the coal-rich Fort Union Formation.

Data collected from the project will be used to determine the amount and quality of ground-water discharge to the Tongue River between the dam, which is near the Wyoming-Montana boundary, and the mouth of the river at Miles City. Stream discharge and quality will be correlated with aquifers along the stream with the aid of aerial infrared (thermal) photography and water levels in wells. Data will then be used to refine predictive techniques of estimating the potential impacts of energy-fuels development on the hydrologic regime of the Tongue River valley and similar valleys.

OTHER, RELATED INVESTIGATIONS

Hydrology of the Madison Limestone and Associated Rocks in Parts of Montana, Nebraska, North Dakota, South Dakota, and Wyoming (Project CR76-192)

Funds: U.S. Geological Survey

Major development of coal within the area will place a heavy demand on the area's limited water resources. Surface water is poorly distributed in time and space. It is fully appropriated in part of the area, and in the rest its use will require storage reservoirs and distribution systems. Preliminary studies indicate that the Madison Limestone (Madison Group) and associated rocks might provide a significant percentage of the total water requirements for coal development. However, the effects of large sustained withdrawals of water from these rocks on the hydrologic system are not known.

The objectives of the 5-year hydrologic study of the Madison Limestone and associated rocks (fig. 10) are to evaluate the quantity of water that may be available from the Madison; define the chemical and physical properties of the water; determine the effects of existing developments on potentiometric head, storage, recharge and discharge, spring flow and streamflow, and pattern of ground-water flow; predict the possible hydrologic effects of proposed withdrawals of water for large-scale developments at selected rates and locations; determine the optimum locations for wells and the type of construction and development of deep wells to obtain maximum yields; and design a network of observation wells and streamflow gages to monitor effects of additional developments on the hydrologic system.

The approach will be to assemble, review, and assess the available geologic and hydrologic data, reports of prior studies, and oil company information; purchase borehole and surface geophysical information and other pertinent data from oil companies; define the structure and stratigraphy of the aquifer; determine the aquifer boundaries and geologic parameters that control permeability; translate these parameters into hydrologic terms; design a test-drilling program; drill and test the aquifer; refine the preliminary digital simulation model of the system and design a monitoring network; predict the effects of various patterns of water-supply development on the potentiometric surface, recharge, discharge, springs, streamflow, and water quality that could result from these developments; operate the monitoring network; and refine the predictions.

Additional information on this study may be obtained from Elliott M. Cushing, Lakewood, Colorado, telephone (303) 234-2018.

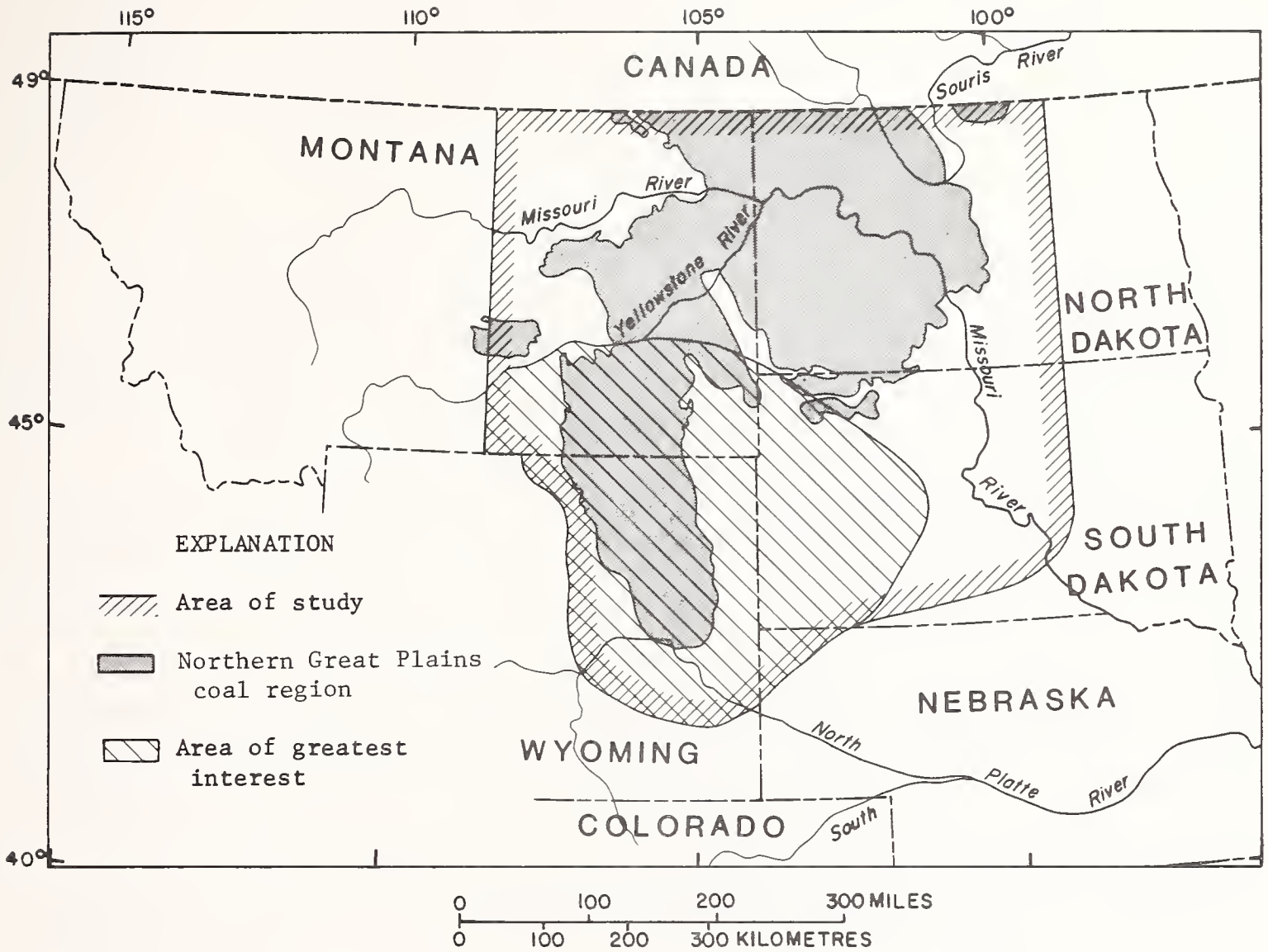

Figure 10.--Location of regional study of Madison aquifer.

Bear Creek EMRIA Study Site near Ashland, Montana
(Project CR75-104)

Funds: U.S. Geological Survey and Bureau of Land Management

The Public Lands Hydrology Program is conducting reconnaissance studies on the 3,200-acre Bear Creek EMRIA Study Site near Ashland, Montana (see reclamation study, fig. 9) to provide data for evaluating the reclamation potential of that area after prospective surface mining for coal.

A map showing annual source-area sediment yields is being prepared and the relations of sediment yield to percentage bare soil and average watershed slope will be described for use in surrounding areas having similar climate and watershed characteristics. Estimates will be made of the amount of sediment contributed from the study site area to Bear Creek.

A map of the vegetation-soil units on the site was prepared from aerial photographs and on-site measurements. Vegetation, mulch, rock cover, and percentage bare soil were measured in each unit. Internal water stress in the woody plants present was also measured. Small plots of vegetation were clipped to determine the yield of the various species.

Soil samples were obtained to the depth of active rooting in each vegetation-soil unit. The depth of rooting was used along with moisture-retention forces and bulk density of the soil to estimate the annual evapotranspiration. The weight of roots, electrical conductivity, pH, and relative erodibility were measured for each soil sample in the laboratory. These data will be useful in selecting suitable vegetation species for rehabilitation of the area if it is mined and in determining whether or not furrowing, pitting, or terracing will be needed to enhance vegetation establishment and to minimize runoff and erosion.

Additional information on this study may be obtained from Richard F. Hadley, Lakewood, Colorado, telephone number (303) 234-4175.

Channel Changes in the Powder River
(Project CR75-102)

Funds: U.S. Geological Survey

After it leaves the Bighorn Mountains, the Powder River flows in an alluvial channel. Like other alluvial channels, that of the Powder River is constantly shifting by erosion, lateral accretion, and occasional cutting off of bends. As of now, the channel of the Powder River and the rates at which it shifts have been affected very little by human activities.

Rates of channel migration will be measured in the 170-kilometre reach of the Powder River between Arvada, Wyoming, and Broadus, Montana (fig. 9). This reach was selected because sediment loads are sampled daily at Arvada, at Moorhead (about halfway down the reach), and at Broadus. Another reason for the selection of this reach is that it contains the site of a proposed reservoir to store water for energy development. If the reservoir is built, its effects on the river channel can be assessed from the available data.

Fieldwork conducted to date has been on the river below Moorhead. It consisted of surveying and marking cross sections of the river that will be resurveyed in subsequent years to measure the rates at which the channel shifts.

Additional information on this study may be obtained from Robert H. Meade, Lakewood, Colorado, telephone number (303) 234-2320.

Geochemical Survey of Waters of the Western Coal Regions
(Project CR74-095)

Funds: U.S. Geological Survey

The purpose of this project is to provide a broad-scale description of the "natural" or predevelopment geochemistry of waters in the western coal and oil shale areas, with particular emphasis on trace elements. The project is being conducted in association with concurrent studies on soils, rocks, and plants by Geologic Division, Branch of Regional Geochemistry.

To date field sampling and laboratory analysis have been completed for waters of the Tertiary Fort Union Formation in North Dakota and Montana. The data are presently being analyzed. The finding of relatively high values of naturally occurring organic nitrogen associated with ground water in coal has prompted a study into the identification of specific organic nitrogen compounds present. The analytical work for this study is presently in progress.

By the end of fiscal 1976, sampling of ground waters in the Northern Great Plains coal region of Wyoming and Montana will be completed.

Additional information on this study may be obtained from Gerald L. Feder, Lakewood, Colorado, telephone number (303) 234-2404.